§8. Computational Study of LHD Equilibrium with $n = 1$ Island

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A Large Helical Device (LHD) equilibrium with $n = 1$ islands are numerically studied by using the three dimensional MHD equilibrium code HINT with a full torus calculation. Here, m is a poloidal mode number and n is a toroidal mode number. An LHD equilibrium with $n = 1$ islands is required in the local island divertor (LID) experiment [1, 2]. Also, there is a possibility that $m/n = 2/1$ islands are produced by error magnetic fields. In this report, we will dare to analyze the equilibrium with $m/n = 2/1$ islands, to counter a case where the islands are not canceled completely and remain in the plasma region.

An LHD equilibrium with the $m/n = 2/1$ island, which are produced by error magnetic fields, is calculated for cases of several beta values. Here, we assume that in these calculations, the outside of a flux surface with the rotational transform of $\iota/2\pi = 1$ is deleted by a limiter and the currentless condition is satisfied. Poincaré plots of magnetic field lines for the vacuum are given in Fig. 1a. The vacuum magnetic field is defined

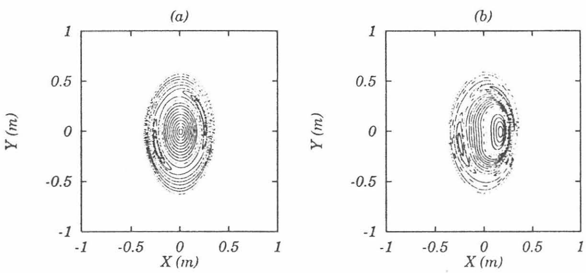

Figure 1: Poincaré plots of field lines at the vertically elongated poloidal cross-section: (a) the vacuum and (b) $\beta_0 = 2.8$ % without a net toroidal current. Here β_0 means the central beta.

in a case of $B_0 = 3$ T and $R_0 = 3.75$ m, where B_0 and R_0 are the strength of magnetic field at the magnetic axis and the major radius of the axis for the vacuum, respectively. A pressure, defined by the peaked profile $p = p_0(1 - s)^2$, is provided into the vacuum field, and this situation is chosen to be the initial condition of relaxation equations. Here, p_0 is a value of pressure at the axis and s the normalized toroidal flux. For a case of the central beta $\beta_0 = 2.8$ %, the Poincaré plots are given in Fig. 1b. The magnetic axis is shifted to the outside of torus and moves to $R_0 = 3.92$ m. Magnetic flux surfaces are slightly distorted near the origin $(X, Y) = (0, 0)$, as is shown in Fig. 1b.

When a value of the central beta is raised to $\beta_0 = 5.4$ %, half of flux surfaces are destroyed and become islands or stochastic regions and the remains of surfaces are violently deformed, as is shown in Fig. 2a. The

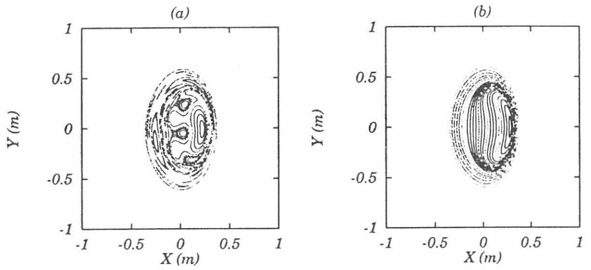

Figure 2: Poincaré plots of field lines under the currentless condition: (a) $\beta_0 = 5.4$ % with $m/n = 2/1$ islands and (b) $\beta_0 = 7.8$ % without $n = 1$ islands.

$m/n = 2/1$ islands themselves are surrounded with the stochastic sea. The equilibrium beta value in the case with $m/n = 2/1$ islands is limited under $\beta_0 = 5.4$ %. Here, the beta limit is defined as a beta value at which half of surfaces are broken. While, an equilibrium without $n = 1$ islands holds flux surfaces firmly and there is no stochastic sea, see Fig. 2b. As a result, we find that flux surfaces in an LHD equilibrium with $m/n = 2/1$ islands are easily broken for higher beta cases, as compared to the equilibrium without the islands.

References

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